CGS NPDES
Comment
#002

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UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1201 NE Lloyd Boulevard, Suite 1100
Portland, OR 97232

February 28, 2014

Jim La Spina
Energy Facility Siting Specialist
Washington Energy Facility Site Evaluation Council
P.O. Box 43172
Olympia, WA 98504-3172

Re: National Marine Fisheries Service (NMFS) comments on Columbia Generating Station National Pollutant Discharge Elimination System (NPDES) Permit No. WA-002515-1 and accompanying Fact Sheet

Dear Mr. LaSpina:

This letter conveys the comments and concerns of National Marine Fisheries Service regarding the proposed NPDES permit renewal for the Columbia Generating Station (CGS), near Richland, Washington. We also take this opportunity to respond to questions you have raised (e-mail of January 29, 2014 from Jim LaSpina, EFSEC, to Rich Domingue, NMFS) regarding our involvement in this permitting process.

We previously commented on the pre-public review draft (Letter of August 6, 2013, attached), expressing concern that the existing cooling water intake screening system posed an unacceptable risk to juvenile salmon and steelhead that may encounter them. As Washington's Energy Facility Site Evaluation Council (EFSEC) has chosen to not adopt our recommended changes in the draft permit, our prior comments and concerns remain relevant. At that time, we recommended that the draft permit be modified to require Energy Northwest ((ENW) – the project owner and operator) to bring the screens into compliance with NMFS' Anadromous Salmonid Passage Facility Design manual's fish passage criteria. During November 2013, ENW staff and their consultant provided us with additional information regarding the design of the intakes and their analysis of the likely effects of intake operation on anadromous fish. NMFS responded to this analysis with a letter to ENW (letter of December 12, 2013 – attached) which we shared with you.

On February 3, 2013, EFSEC released its draft NPDES permit and accompanying fact sheet for the CGS. We have reviewed this permit and fact sheet and offer the following comments.

General Comment:
NMFS disagrees with EFSEC's determination in the associated Fact Sheet (the draft permit is silent regarding the cooling water intake structure) that the existing cooling water intake screens represent the best available technology to minimize adverse environmental effects. NMFS has extensive experience in fish exclusion and passage systems, has evaluated the CGS intake screen designs and supporting studies, and has determined that they are notably out-of-date and would likely harm some of the juvenile salmon that encounter them. Our specific comments on analyses presented in your Fact Sheet follow.

Specific Comments:
Page 24. The Energy Facility Site Evaluation Council presents its determination that NMFS' juvenile fish screen criteria contained in NMFS' Anadromous Salmonid Passage Facility Design manual do not apply to the CGS: "EFSEC has determined that this guidance is not applicable to CGS, an existing facility, based on the applicability statement in the document itself and the absence of information indicating impingement or entrainment of listed species from the intake structures."

The applicability statement referenced from NMFS Anadromous Salmonid Passage Facility Design manual is:

> *"Existing facilities may not adhere to the criteria and guidelines listed in this document. However, that does not mean these facilities must be modified specifically for compliance with this document. The intention of these criteria and guidelines is to ensure future compliance in the context of major upgrades and new designs of fish passage facilities."*

The Energy Facility Site Evaluation Council assertion that by that statement, NMFS effectively foreclosed application of the criteria to existing facilities not undergoing major upgrades and new fishway designs is incorrect. NMFS Anadromous Salmonid Passage Facility Design manual is a guidance document, applicable at NMFS' sole discretion under the particular factual situation. The fish screen criteria contained in the manual are based on field and laboratory studies, are designed to provide a high level of protection to juvenile salmonids, and have been widely accepted, including by Washington's Department of Fish and Wildlife. NMFS screen criteria are available on NOAA Fisheries Service West Coast Regional website, (http://www.westcoast.fisheries.noaa.gov/publications/hydropower/fish_passage_design_criteria.pdf), and are used as the basis for screen design for any new or existing water intake where NMFS has a current jurisdictional involvement, and the existing water intake screen design (or lack thereof) provides inadequate fish protection. NMFS generally does not pursue existing facilities for screen design revisions unless there is current evidence of Endangered Species Act (ESA) species take, or until a new Federal action requires ESA consultation with NMFS. The U.S. Nuclear Regulatory Commission's relicensing of the CGS is such a new Federal action. Effects associated with implementing the NPDES permit are effects of NRC's relicensing action upon which we are consulting.

As regards to the lack of evidence of harm to ESA-listed salmon and steelhead cited as justification for your determination that the existing intakes are highly protective, the evidence from entrainment studies conducted during the 1980s is weak. NMFS provided its assessment of these studies to EFSEC during the pre-public review process. We are attaching these prior comments and a DVD containing the references cited for your ready reference.

The position that listed fish of a small enough size to be affected by the intakes do not occur in their vicinity is incorrect. Recent steelhead redd surveys conducted by the U.S. Department of Energy in the Hanford Reach of the Columbia River has verified upper Columbia River steelhead spawning in the vicinity of CGS. [1] Prior work on the cross-sectional distribution of juvenile Chinook and steelhead in the Hanford Reach found juveniles of both species throughout the river cross-section, indicating that both yearling and sub-yearling juvenile ESA-listed fish likely occur in the vicinity of the CGS intakes. [2] We have included copies of these reports for your use on the enclosed disk.

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[1] USDOE. 2014. Hanford Site Steelhead Redd Monitoring Report for Calendar Year 2013. Prepared for the U.S. Department of Energy Assistant Secretary for Environmental Management.
[2] Dauble, D.D., T.L. Page, and R.W. Hanf. 1989. Spatial distribution of juvenile salmonids in the Hanford Reach, Columbia River. U.S. Fishery Bulletin 87:775-790

Further, the Hanford reach of the Columbia River is the primary spawning location for upper Columbia River summer/fall Chinook salmon. While this Evolutionarily Significant Unit (ESU) is currently healthy and not listed under the ESA, its essential habitat, including river substrate, is protected under the Magnuson-Stevens Fishery Conservation and Management Act (MSA). NMFS is charged with implementing the MSA. Abundant fry from this species utilize essential fish habitat in the project vicinity and are susceptible to impingement and entrainment at the intakes.

Page 24-25, Conclusions. This section references ENW's arguments that hydrodynamic effects of the intake structures and fish behavior lead to very small risks to ESA-listed salmon and steelhead juveniles at the intakes, but fails to acknowledge NMFS' rebuttals to those arguments that were provided to EFSEC (letter of December 12, 2013 - attached). Failure to consider our responses indicates that EFSEC's approach to developing its best professional judgment is incomplete.

Responses to questions raised in Mr. Jim LaSpina's email of January 30, 2014.

1. What is the status of the consultation between NMFS and the U.S. Nuclear Regulatory Commission (NRC) regarding CGS?

    NMFS and NRC remain in consultation. The process is in abeyance until there is a complete proposed action on which we could complete consultation. The proposed action cannot be fully defined until the NPDES permit is issued. NRC requested our concurrence with its determination that the project was not likely to adversely affect listed species. Due to the outdated design of the intake structures that risks impingement and entrainment of juvenile fish, we could not concur. Further, certain actions required by your current permit, (e.g. electrofishing for bioassay monitoring) presents risks of harm to ESA-listed fish. To provide NRC and ENW (and potentially the State of Washington) with coverage for potential harm to listed fish from operation of intake screens and electrofishing monitoring would require us to complete formal consultation. To be clear, we cannot exempt electrofishing in occupied habitats not associated with scientific research from the prohibitions of take without a formal consultation.

2. Why not pursue NRC to complete its consultation?

    The NRC represents that it cannot modify in any way conditions imposed under an NPDES permit. Nevertheless, in its ESA Section 7(a)(2) consultation with NMFS, the effects of the cooling water intake structure and other aspects of the project regulated by the NPDES permit, are considered part of the total effects of operating the plant pursuant to the NRC license. Hence, our involvement in this NPDES permit process is to ensure that the permit that issues comports with the ESA, facilitating completion of our consultation with the NRC.

    Our usual course for ensuring protection of ESA-listed species and their critical habitats in consultations on Federal permitting actions is to use the authorities of the Federal permitting agency to modify the permitted action as needed. Our sole reason for involvement in EFSEC's issuance of a new NPDES permit for this project is the NRC's lack of authority to implement protective measures for facilities covered under the project's NPDES permit. Hence, we are seeking EFSEC to employ its Federally-approved authority under the Clean Water Act to issue a new NPDES permit that regulates the cooling water intake structure and other aspects of this facility's operation to protect ESA-listed species.

We appreciate the opportunity to comment on this important action. Should you have any questions with regard to these comments, please call or e-mail Rich Domingue of my staff (503-231-6858, richard.domingue@noaa.gov).

Sincerely,

Michael P. Tehan

Michael P.Tehan
Assistant Regional Administrator
Interior Columbia Basin Office
NOAA Fisheries, West Coast Region

Cc: Shannon Khounnala, ENW
Dennis Logan, NRC
Bill Moore, WDOE
Peggy Miller WDFW
Karen Burgess, EPA

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1201 NE Lloyd Boulevard, Suite 1100
Portland, OR 97232

December 12, 2013

Shannon Khounnala
Energy Northwest
Mail Drop PE20
PO Box 968
Richland, WA 00352-0968

Re: Columbia Generating Station Cooling Water Intake Screen
NMFS Consultation No. (I/NWR/2011/05286)

Dear Ms Khounnala:

This letter responds to information you, other Energy Northwest (ENW) staff, and Dr. Chuck Coutant provided to us during our meeting on November 13, 2013. We appreciate the time and effort ENW expended to better inform us as to the risks of fish impingement and entrainment (I&E) posed by the project's cooling water intakes. We have reviewed the materials provided during that meeting to determine whether they sufficiently address the issues that have caused us to object to the National Pollutant Discharge Elimination System (NPDES) permit Washington's Energy Facility Site Evaluation Council (EFSEC) is currently proposing to issue. Our review is attached. We remain concerned that the existing Columbia Generating Station Cooling Water Intake Screen (CWIS) poses a risk of injury or mortality to fry and juvenile salmon and steelhead that rear near or migrate past the facility, including fish protected by the Federal Endangered Species Act (ESA).

We continue to recommend that the CWIS be modified to minimize the potential for I&E. We further recommend that monitoring actions that require electrofishing in the Columbia River for purposes of the NPDES permit be covered by an ESA 'take' authorization. The state's NPDES permit is essential for successfully completing an ESA Section 7(a)(2) consultation, biological opinion and incidental take statement, for the Columbia Generating Station's operation and maintenance under its Nuclear Regulatory Commission license. A NPDES permit that is sufficiently protective of ESA listed salmon and steelhead will allow for an operation of the Station that can comply with ESA standards.

Please do not hesitate to call us if you have any questions. Rich Domingue (503-231-6858) can provide information on formal consultations, and Bryan Nordlund, P.E. can answer questions regarding screen design and operation.

Sincerely,

Michael P. Tehan

Michael P. Tehan
Assistant Regional Administrator
Interior Columbia Basin Area Office
NOAA Fisheries, West Coast Region

cc: Jim LaSpina
Energy Facility Siting Specialist
Ecology/Energy Facility Site Evaluation Council
P.O. Box 43172
Olympia, WA 98504-3172

Enclosure: Memorandum from Bryan Nordlund:
Review of recent info regarding Columbia Generating Station

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
1201 NE Lloyd Boulevard, Suite 1100
Portland, OR 97232

December 12, 2013

MEMORANDUM FOR: Ritchie Graves

CC: Rich Domingue

FROM: Bryan Nordlund

SUBJECT: Review of recent info regarding Columbia Generating Station

1985 Entrainment Report[1]

I reviewed the material provided by Energy Northwest (ENW) staff at the November 13, 2013 meeting held in our Portland office. Specifically, I reviewed Section 12.0 from "Operational Ecology Monitoring Program for Nuclear Plant 2 1985 Annual Report". Section 12.0 was the only section of this report provided by ENW, and the only section of this report that I reviewed.

Section 12 pertained to monitoring entrainment in the Columbia Generating Station (CGS) intakes and beach seine monitoring upstream and downstream of the CGS intakes. No entrainment was recorded in 1985 in weekly samples taken from April 3 to May 5, and again from July 23 to September 11.

Although this data suggests that no entrainment occurred during the testing, there are a few monitoring deficiencies to consider. First, there is only a rudimentary description and diagram of the entrainment capture cages. Flow was diverted through the intake screens from the river, and routed into the cages, which were rectangular boxes. No control release was reported, so presumably a control release was never conducted. This is unfortunate because the Chinook fry captured by seine net were small, with fork length ranging from 36-62 mm, with an average of 43 mm. Fry of this size are notoriously hard to recapture, especially in high velocity flow, because of their poor swimming ability and their propensity to seek refuge in calmer waters. From my review of mark recapture screen studies involving fry (see Appendix A), some portion of the control fish were never recaptured in nearly all or all of the studies - this does not mean they were not entrained, it only means they were never recovered. The number of control fish

[1] Washington Public Power Supply System, 1985. Operational Ecologcal Monitoring Program for Nuclear Plant 2, 1985 Report. Section 12. Prepared by Environmental Programs Department. WPPS, Richland, WA.

not recaptured was used to adjust estimates of mortality and injury. In the case of the CGS entrainment studies, there is no way to tell whether any or how many fish entrained from the river intake were captured in the cages.

Because the intake flow is low relative to the total river flow (Section 12 states 0.08%), the number of entrained fish would likely be low. If some fish were entrained, they could have been lost in the capture cage via poor seals, poor joints between mesh panels, mesh distortions, gaps at the closure gates or spillback of flow into the sump while the capture gate was open. If flow plunges from the pipe into the cage situated in a sump area of the intake, there is likely a portion of the cage's perimeter that is relatively quiescent beneath the impact of the plunge. Fish could potentially jump from the cage interior at the plunging flow and wind up undetected in the sump area. In addition, any gap in the cage larger than 1.75 mm could allow an escape path for fry. Without a detailed drawing of the capture cage, there is no way to assess whether escape paths were present. Without a pre-test inspection of the capture cage, there is no way to tell whether the design remained intact through the duration of the testing - a collision with the relatively fragile woven wire mesh could create an escape path. A mis-alignment of the capture cage with the intake pipe could also create an escape path for fish entrained at the CGS intake. Many of these physical deficiencies in the capture cages, whether real or potential, could have been corrected to account for escaped entrained fish if a control release were made to calibrate the efficiency of the capture cage.

With the relative flow amount so small, entrainment detection studies would need to be much more rigorous to capture any fish from the CGS intake.

Lastly, the size of the fish (36-62 mm) captured in the seine nets largely reflect the size of fish captured in an extensive spatial distribution study ("Spatial Distribution of Juvenile Salmonids in the Hanford Reach, Columbia River", Dennis D. Dauble, Page T.L. and Han Jr., R.W., U.S. Fishery Bulletin 87:775-790, May 1989) conducted near the CGS intake from July to September 1983, and again from April to June 1984. As demonstrated in my July 31, 2013, memo for Hydro Division files, the size of these fish makes them susceptible to entrainment at the CGS intakes.

2013 Coutant Memo [2]

I also reviewed a discussion paper titled "Why Cylindrical Screens in Flowing Water Impinge and Entrain Few Fish, and Its Importance for The Columbia Generating Station", authored by Charles C. Coutant, Ph.D. for Energy Northwest on November 7, 2013 (Report).

[2] Coutant, C.C. 2013. Why Cylindrical Screens in Flowing Water Impinge and Entrain Few Fish and its Importance for the Columbia Generating Station's Intake. Prepared by Charles C. Coutant for Energy Northwest, Richland Washington.

Dr. Coutant raises several points in his Report that are not entirely correct.

1) The Report interprets the results from a fish screen study at the Indian Point intake in the Eastern U.S. as providing unique insight as to how flow dynamics for a cylindrical screen (similar to the CGS screens) affect fish behavior around the screen to provide lower rates of entrainment as compared to screens that rely on approach velocity and screen opening size to exclude fish, which he implies is the basis of design for NMFS screen criteria. It is correct that flow dynamics in and around the screen face influence fish behavior, but incorrect in the assumption that this is not considered in NMFS screen design criteria. He is also incorrect in his assumption that this behavioral response is unique to cylindrical screens. In fact, each style of screen design currently in NMFS Design Manual (including cylindrical screens, which are a type of end of pipe screens, as described in NMFS 2011) relies partially on behavior to allow some fish to avoid the screen face entirely. Those fish that are incapable or do not behave to avoid the screen face (due to various combinations of flow anomalies, weak swimming ability, startle response etc.) are excluded from impingement by low approach velocity (Va) perpendicular to the screen face; are excluded from entrainment by small mesh openings; and are swept away from the screen by high sweep velocity (Vs) parallel to the screen face. This could partially explain why the Indian Point intake excluded around 90% of eggs, larvae and fry. A screen design to NMFS criteria typically excludes over 98% of Chinook fry, and sometimes up to 100%. It could well be that 90% of fish that encounter any style of screen (with a route of egress or bypass) are not entrained, and the remainder of the fish that are not entrained, impinged, killed or injured are protected by the mesh size and approach velocity. Regardless of the precise number, mesh openings that physically preclude a fish's body from entrainment both intuitively and factually increase the chance of survival.

2) It is stated in the Report that 3/8" pore size is common for fish screens. This is untrue in the Western Region, as Federal and state screen criteria are all identical to those specified in NMFS Design manual: 1.75 mm slots or 3/32" square or round opening size are called for where juvenile salmon are present. Nearly all (or possibly all) screen installations constructed after 1990 use this criterion.

3) It is stated in the Report that many screen sites with low debris load and high ambient river velocity do not need cleaning systems. This is a risky design in terms of fish protection and structural integrity, and is not the case in the Pacific Northwest except for very small screens (less than 3 cfs) with particular hydraulics. Debris load is often considered a minor issue by those inexperienced in screen design, and underestimating this issue in design has caused screen facilities to fail catastrophically. I note that a behavioral device tested by Dr. Coutant in the Cowlitz basin failed when debris accumulated and overwhelmed the facility rendering it ineffective and inoperable. It has since been removed.

4) It is claimed in the Report that due to a "bow wave" created by the design of a cylindrical screen, momentum moves particles away from a cylindrical screen's face, allowing water to enter and particles (such as fish) to be deflected away from the screen. This is true for any object in the path of water. The "bow wave" (called a null velocity point by hydraulic engineers) will vary depending on the shape of the object and the velocity of the flow around the object. What Dr. Coutant fails to point out regarding the figures in his report, is that the "bow wave" collapses after initiation, and the flow steamlines once again converge on the cylindrical screen face. The color contours in the Report Figure 1 show this clearly. This figure also highlights my point about the shape of the "bow wave" being dependent on flow velocity - the two modeled shapes in the Report's Figure 1 show low and high velocity flow fields around the same object. The collapse of the "bow wave" places any fish initially deflected by the nose cone, near the screen face and subject to entrainment, and this will vary with flow amount and river velocity. This also affects the ability of a screen face to rely on ambient velocity or sweeping velocity to shed debris, which is a primary factor for establishing a requirement for a screen cleaner.

5) Grant PUD, at two dams upstream of the CGS intake, often reports issues with large milfoil mats breaking loose near the end of summer. At dozens of fishway inspections, I personally conducted at these two dams, my inspection reports frequently point out debris accumulations that require removal by Grant PUD fishway attendants. The assertion in the Report that the Columbia River is relatively debris free is not accurate.

6) The Report states that "... at the test cylindrical screen, . . . entrainment prevention by these factors increase[s] with fish size.", referring to behavioral reactions to the "bow wave". Instead, I note that bigger fish have higher swim speeds, which allows them to swim away from the screen face and not be entrained. In addition, many types of fishes utilize hydraulic anomalies including null point or "bow waves" as velocity refuge to hold around natural or man-made objects. This behavior may extend the time period for fish exposed to the screen.

7) I also question the Report's assertion that eggs and larvae can exhibit any behavior to prevent them from being entrained, because generally they cannot swim.

8) The Report noted that juvenile salmon migrate downstream with their heads pointing upstream, which in many cases is true. However, at this site, many juvenile salmon are not migrating. Instead, they are rearing fish. As such, any assumption that tail first downstream migration impacts behavior due to lateral line detection of screen hydraulics is not accurate in a general case. In addition, it is not migratory juvenile salmon that are likely to be entrained through the 3/8" screen openings at the CGS intake because of their physical size. Instead, smaller rearing juvenile salmon - mostly Hanford Reach fall Chinook parr, but possibly some listed steelhead fry as well - would probably be wandering around the intake site foraging, and subject to entrainment at the CGS intake or to predation by piscivores taking advantage of the "bow wave" created by the CGS screen structure. However, I note that my recommendations for screen improvements at the CGS intake would not reduce predation potential.

9) The Report discusses baffle systems that are common on the East Coast to reduce entrainment through a water diversion, and makes a comparison to the CGS cylindrical screens, implying that fish behavior at baffle installations reduce entrainment. This is true enough for larger fish. However, we stopped using baffle systems on the West Coast because they entrain smaller fish when they are present.

10) The Report refers to an impingement study that shows no impingement. I question how valid this study could be, with only 9 hours of subjective observation in the past 30 years or so. If fish were impinged, predators or scavengers would likely remove any evidence. That said, I would not expect impingement of juvenile salmon to be observable at the CGS intake, because

small fish would be entrained not impinged, and larger fish could likely avoid impingement by behavioral reaction and swimming ability.

11) The Report implies that due to the "bow wave" shown in Figure 1, the CGS intake would not entrain fish. Figure 1 is a mathematical model based on some other screen site, and it may or may not be representative of the CGS screens.

12) The report generally concludes that "... there will be little vulnerability of migrating fish larger than about 20 mm (0.8 in.) to a porous cylindrical screen." Juvenile salmon smaller than about 90 mm are rarely migratory, and are present in the vicinity of the CGS intake. The vulnerability posed to juvenile salmonids from the CGS intake can be corrected to eliminate the potential of any juvenile salmon less than about 70 mm fork length to be sucked into the CGS intake as demonstrated in my previous file memo.

13) The Report misses another vulnerability for fish near the CGS intake posed when debris accumulates on the screen face, thereby reducing flow-through screen area and increasing screen approach velocity to the point where even larger fish could be impinged.

14) The Report misses yet another vulnerability to juvenile salmonids posed by occasional shallow depths over the CGS screens, which creates a higher velocity field on top of the screens. Since velocity equals flow divided by area, the higher velocity field is created when a smaller flow area results because of the narrower dimension between the top of the screen and the water surface, with the intake flow relatively unchanged as compared to a higher submergence. If a fish is caught in this higher velocity field above the screens at lower river elevations, the behavioral response aspect of fish protection is reduced, because the lateral line mostly or entirely cannot detect flow fields beneath the fish.

15) The Report states that emergent and "button-up" salmon and steelhead fry are unlikely to be present near the CGS intake because they are in the gravel, and further states that any juvenile salmon present are too large to be entrained through the 3/8" CGS screen openings (apparently

discarding the previous argument that fish behavior at a cylindrical screen precludes entrainment). This is weak, because clearly, at some point fry emerge from the gravel and would be subjected to the CGS intake. The spatial distribution study (Dauble, 1989 referenced earlier) clearly shows that juvenile salmon of size that could be entrained are present at the CGS site.

Appendix A - Selected screen and bypass studies in the Pacific Northwest

Bigelow, J.P. and R.R. Johnson. 1996. Estimates of Survival and Condition of Juvenile Salmonids passing Through the Downstream Migrant Fish Protection Facilities at Red Bluff Diversion Dam on the Sacramento River, Spring and Summer 1994. U.S. Fish and Wildlife Service Annual Report. North Central Valley Fish and Wildlife Office, Red Bluff, California

Hosey and Associates and Fish Management Consultants. 1988. Chandler Facility Evaluation. Prepared for U.S. Bureau of Reclamation, Contract No. 7-CS-10-07720, Boise, Idaho.

Hosey and Associates and Fish Management Consultants. 1990. Evaluation of the Chandler, Columbia, Roza and Easton Screening Facilities, Completion Report. Prepared for U.S. Bureau of Reclamation, Contract No. 7-CS-10-07720, Boise, Idaho.

Hosey and Associates and Fish Management Consultants. 1990. Easton Facility Evaluation. Prepared for U.S. Bureau of Reclamation, Contract No. 7-CS-10-07720, Boise, Idaho.

Johnson, R.C. 1995. Fish Passage Evaluation Tests in the North Shore Fishway Hydroelectric Project at The Dalles Dam. Prepared for North Wasco County People's Utility District, The Dalles, Oregon.

Knapp, S.M. (editor). 1992. Evaluation of the Juvenile Bypass and Adult Fish Passage Facilities at Water Diversions on the Umatilla River, Annual and Interim Progress Reports October 1990-September 1991. Project No. 89-024-01. Prepared for Bonneville Power Administration, Portland, Oregon.

Knapp, S.M. (editor). 1994. Evaluation of the Juvenile Bypass and Adult Fish Passage Facilities at Water Diversions on the Umatilla River, Annual Report 1993. Project No. 89-024-01. Prepared for Bonneville Power Administration, Portland, Oregon.

Mueller, R.P., C.S. Abernathy, and D.A. Neitzel. 1995. A Fisheries Evaluation of the Dryden Fish Screening Facility Annual Report 1994. Project No. 85-062. Prepared for Bonneville Power Administration, Portland, Oregon.

Nietzel, D.A., C.S. Abernathy, E.W. Lusty and L.A. Prohammer. 1985. A Fisheries Evaluation of the Sunnyside Canal Fish Screening Facilities Spring 1985 Annual Report. Contract No. DE-AC06-RLO. Prepared for Bonneville Power Administration, Portland, Oregon.

Nietzel, D.A., C.S. Abernathy and E.W. Lusty. 1990. A Fisheries Evaluation of the Westside Ditch and Wapato Canal Fish Screening Facilities Spring 1989 Annual Report. Project No. 85-62. Prepared for Bonneville Power Administration, Portland, Oregon.

Nigro, A.A. (editor). 1990. Evaluation of the Juvenile Bypass and Adult Fish Passage Facilities at Three Mile Dam, Umatilla River, Annual Progress Report October 1989. Project No. 89-024-01. Prepared for Bonneville Power Administration, Portland, Oregon.

Ruehle, T.E. and C.S. McCutcheon. 1994. PIT-Tag Studies with Juvenile Salmonids at the Chandler Fish Collection Facility, Yakima River, 1990. Project No.90-65. Prepared for Bonneville Power Administration, Portland, Oregon.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
1201 NE Lloyd Boulevard, Suite 1100
PORTLAND, OREGON 97232-1274

August 6, 2013

Jim La Spina, Energy Facility Siting Specialist
Washington Energy Facility Site Evaluation Council
P.O. Box 43172
Olympia, WA 98504-3172

Re: NMFS comments on Columbia Generating Station National Pollutant Discharge Elimination System (NPDES) Permit No. WA-002515-1 and accompanying Fact Sheet

Dear Mr. Spina:

We appreciate this opportunity to comment on the above referenced permit prior to public review and issuance. As you know, we are concerned that the cooling water intake screening system may impinge and entrain juvenile salmon and steelhead and have met with you and Washington Department of Ecology (WDOE) staff several times to express our concerns.

The permit itself is silent on this intake structure. Washington Department of Ecology/Energy Facility Site Evaluation Council (EFSEC's) determination that this facility conforms with Clean Water Act (CWA) Section 316(b) is provided by the Fact Sheet accompanying the proposed permit which includes a determination that the existing screen system is the best technology available (BTA) for minimizing adverse environmental impacts based on WDOE staff's best professional judgment. We disagree that the existing screen system is BTA.

The facility is located within the Hanford Reach of the Columbia River, which is used by spawning upper Columbia River steelhead; a distinct population segment listed as threatened under the Endangered Species Act (ESA), and is the primary spawning location for upper Columbia River summer/fall Chinook, the healthiest salmon Evolutionarily Significant Unit (ESU) in the basin. Threatened upper Columbia River steelhead and their designated critical habitat are protected under the ESA and the essential fish habitat (including spawning and rearing habitats in the project area) of upper Columbia River summer/fall Chinook salmon is protected under the Magnuson Stevens Fishery Conservation and Management Act, both of which are administered by NMFS for these species. Fry and rearing juveniles of these species would be susceptible to impingement and entrainment if they came into contact with the intake. ESA-listed upper Columbia River spring Chinook juveniles also migrate past the facility and may also be adversely affected. NMFS is charged with protecting these species and their critical habitats and promoting their recovery. We believe the continued operation of the existing intake structure in its current configuration places undue risk on these valuable resources.

We have attached a review of these facilities and a review of EFSEC's determination of BTA by Bryan Nordlund, P.E., an expert in fish passage engineering and include his comments by reference and his concerns that the existing screens represent BTA.

Specific Comments

These comments focus on the determination of BTA for this structure, beginning on page 20 of the Fact Sheet.

1. Page 21, para. 5. The design for the intakes dates from the late 1970s, nearly two decades before upper Columbia River steelhead and spring Chinook were listed under the ESA. The status of these species has obviously declined and our understanding of fish passage issues has greatly improved since that time. That is, both our concern for the species and our knowledge of how they are impacted have increased. If asked, NMFS would not approve that design today. Orifice diameters of 3/8 inch pose an entrainment risk and are not protective of all life stages of juvenile salmonids expected to be present at the site (see Nordlund memos). In addition, there is no indication of flow baffling to distribute intake flow evenly over the intake screens, nor is there a cleaning system capable of automatic debris removal. These design flaws may produce areas of localized high velocity on the screen face, which pose an impingement risk to fish. Further, at some river water surface elevations, there may not be sufficient depth over the screen face such that when maximum flow is diverted, small fish may not be able to escape the velocity produced over the screen face. With recent state-of-the-art improvements to the cooling water system (i.e. new, copper-free condenser), the intakes stand out as outdated.

2 Page 21, para. 7. We agree that the recirculating cooling water system has a lower water demand than would a once-through system and thus provides lesser adverse environmental effects.

3. Page 22, para. 3. Post-construction evaluation of the intake screens' effects on salmon were low-effort studies that did not always consider the seasonality of use – entrainment studies conducted when few juvenile fish are in the river likely underestimate the effects that would occur when many fish of a susceptible size are in the river. The attached Nordlund memos document studies that demonstrate the presence of small juvenile salmonids in a location very near and very similar to the Columbia Generating Station (CGS) intake, and the seasonal variability of fish presence.

4. Page 23, para 3. You have taken that statement out of context and thereby misconstrued our intent. The referenced statement from our Anadromous Salmonid Passage Facility Design Manual is intended to allow operation of screens designed to meet prior versions of NMFS screen criteria dated later than August 21,1989, only if can be demonstrated that there is no adverse effect on salmonids per the six bullets listed. Since the existing CGS screens were constructed prior to 1989, and do not meet any prior version of NMFS screen criteria, this statement does not apply to the CGS intake screens.

5. Page 23, para.4. You reference Nuclear Regulatory Commission (NRC) safety requirements as an impediment to modifying the intake screening system to protect fish, yet present no evidence of such impediment. We are fully aware that such safety considerations are imperative and see no reason NRC safety requirements would prevent modification of the intake system to protect fish.

6. Page 24, para. 1. You state, "EFSEC will reevaluate this determination when final rules applicable to the facility are issued and may modify this proposed permit on the basis of new information." This statement is quite vague. If EFSEC is intent on ensuring conformance with new rules, the statement should read, "EFSEC will reevaluate this determination when final rules applicable to the facility are issued and, if necessary, would modify this permit to conform with the new rules." We are confident that an intake designed to meet NMFS juvenile fish screen criteria would also meet EPA's pending new CWA Section 316(b) rules. Furthermore, the pendency of new rules does not excuse compliance with existing rules for cooling water intake structures.

Requested Remedy.

EFSEC should revise the proposed permit to include a requirement for Energy Northwest to work in cooperation with NMFS, the Washington Department of Fish and Wildlife, and NRC to develop and implement a design for the intake screening system that meets NMFS juvenile fish screening criteria within two years of permit issuance. Please see Mr. Bryan Nordlund's memo of July 31, 2013 on Columbia Generating Station (CGS) – Intake Screens Assessment and Recommendations for Modifications, for details on existing inadequacies and recommended modifications.

Should you need additional information to support your action on this matter, please contact Richard Domingue (503-231-6858 or richard.domingue@noaa.gov), or, for additional information on fish protection engineering, please contact Bryan Nordlund (360-534-9338 or Bryan.Nordlund@noaa.gov). Thank you this opportunity to review your proposed permit and fact sheet.

Sincerely,

Bruce Suzumoto
Assistant Regional Administrator
Hydropower Division

Enclosures

cc: Dennis Logan, NRC
Dan Opalski, USEPA

July 31, 2013

MEMORANDUM FOR: Hydro Division Files

CC: Rich Domingue

FROM: Bryan Nordlund, P.E.

SUBJECT: Entrainment and Impingement Potential for Salmonids at the Columbia Generating Station (CGS) Intake Screens

Screen Design Expertise

The following is an assessment of the potential for impingement and entrainment of ESA listed and unlisted salmonids at the CGS intakes for cooling water. This assessment provides my best professional judgment as a fish passage engineer, experienced with the design and operation of fish screens and other fish passage structures in the Upper Columbia River Basin for the past 22 years, and in the Pacific Northwest in general for the past 26 years. I am the primary author of the NMFS' Anadromous Salmonid Passage Facility Design document (NMFS, 2011), which includes screen and bypass design guidance in Chapter 11 (NMFS Screen Criteria). I've collaborated and consulted with all state Federal and tribal fisheries agencies and with NMFS staff to regularly update NMFS Screen Criteria, through the Fish Screen Oversight Committee (FSOC) of the Columbia Basin Fish and Wildlife Authority which oversees fish screening issues in Washington, Oregon, Idaho and Montana. I also am the current chair of FSOC.

Site Specific Screen Entrainment Study Requirements

The option for a paper assessment, such as provided hereafter, is a physical entrainment study. To comprehensively study this issue at the CGS screen site would entail covering the entire salmonid migration period from emergence of fall Chinook fry in the Hanford Reach, to the outmigration of ESA listed spring Chinook and steelhead, to the outmigration of zero age fall and summer Chinook. Typically, around 95% of the outmigration occurs between April 1 and Aug 30. This would need to be conducted over a variety of Columbia River flow conditions across the outmigration, typically between the 5% and 95% exceedence flow levels, and it may take several years to complete the study. In addition, because fish body size and water temperatures vary throughout the year and both of these directly impact swimming ability, it is difficult to achieve conclusive comprehensive results. These studies are always expensive and rarely result in demonstrable evidence that fish are not impinged or entrained at a site with inadequate juvenile fish screens. Since these CGS screens do not meet NMFS screen criteria, or Washington Department of Fish and Wildlife (WDFW) screen criteria, and small juvenile salmonids are present in the vicinity of the intake, there is no question in my mind that entrainment risk always exists and varies with fish presence, depending on the time of day and time of year.

Screen Entrainment
Milo Bell, authored a handbook titled "Fisheries Handbook of Engineering Requirements and Biological Criteria" by Milo C. Bell for the North Pacific Division of the Army Corps of Engineers, 1990 (Bell 1990). Among the extensive array of material that can be found in Bell's Handbook, are a set of equations that are used to predict juvenile salmonid entrainment through screens based on the dimensions of the fish's body. For the CGS screens with 3/8-inch screen openings, these equations predict entrainment of anadromous salmonids smaller than 75 mm body length. In addition, a variety of studies in the lab (Bates and Fuller, 1992) and in the field (Beecher, 1993) (PNNL, 1994) were used to establish the anadromous salmonid criteria for maximum screen face openings, which are 1.75 mm for slotted openings, or 3/32-inch for round or square openings. The NMFS and FSOC (including WDFW) currently use these studies as the basis for criteria for any screen face opening that could allow fish entrainment, including wire mesh screens, slotted screens, link belt screens and perforated plate screens, as well as any other opening in the screen face (for example, seal tolerance).

The equations (page 26.2) in Bell's handbook use fish body length (L) and body depth (D) to calculate the maximum screen opening that will preclude entrainment for a specific fish size, based on the ratio F, which is L divided by D. There are different equations for ranges of F, which generally cover the spectrum of fish species, life stages and fish sizes that are present in the Hanford Reach near the CGS intake. Table 1 below shows the results of using the equation found in the Bell Handbook to calculate entrainment potential for a variety of fish species and life stages, based on body morphology data from a variety of studies. These calculations do not include any consideration of the flexibility and mobility of juvenile salmonids, which can allow entrainment through openings even smaller than those predicted by body morphology.

Table 1: Screen mesh entrainment potential, as predicted by equations from Bell's Handbook.

Species	Body Length and Depth (mm)	Ratio L/D	Predicted minimum mesh size to preclude entrainment (inches)	Entrainment protection with NMFS screens criteria?	Entrainment protection with CGS Screens?	Species/life stage present at CGS site?
Emergent steelhead and Chinook fry	L=25, D=2.5	10.0	1/16th inch	maybe	no	unlikely
Button-up steelhead and Chinook fry	L=35, D =5	7	7/64th inch	yes	no	unlikely
Chinook zero-age	L=50, D=7.5	6.7	1/8th inch	yes	no	yes
Chinook sub-yearlings	L=75, D=12	6.25	3/8th inch	yes	maybe	yes

Chinook sub-yearlings	L=100, D=17	6.3	5/8th inch	yes	yes	yes
Wild steelhead pre-smolt	L=125, D=22	5.7	3/4th inch	yes	yes	yes
Hatchery Steelhead smolt	L=150, D=25	6.0	1 inch	yes	yes	yes

The second is "Spatial Distribution of Juvenile Salmonids in the Hanford Reach, Columbia River", authored by Dennis D. Dauble, Thomas L. Page and R. William Hanf, Jr., and published in 1989 in Fishery Bulletin, U.S. 87:775-990 (Dauble report). The Dauble report consists of study results showing fish capture from deployment of fyke nets in the Hanford Reach in the vicinity of the CGS intake screens, with the fyke nets set in an array representing the entire cross section of the Columbia River.

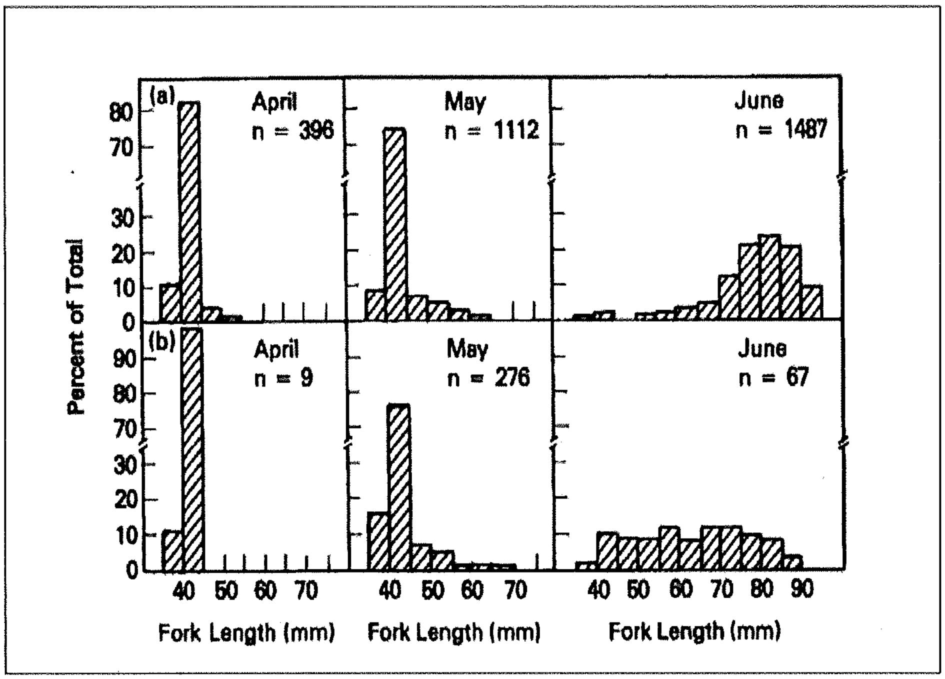

Figure 1. - Length-frequency of 0-age fall Chinook salmon collected with fyke nets: a) barge sets and b) shoreline sets (from Dauble et al, 1989)

NMFS Screen Criteria

In 2011, FSOC adopted NMFS Screen Criteria regionally (Oregon, Washington, Idaho and Montana). NMFS Screen Criteria requires that screen face openings be no greater than 3/32-inch for square or round opening, or 1.75 mm for slotted opening. This criterion for screen face material was derived from laboratory screen mesh tests conducted for a variety of juvenile salmonids in the early 1990's (Bates and Fuller, 1992) (Beecher, 1993), and later modified by considering the results of a screen evaluation at the Dryden canal (Mueller et al, 1995) (PNNL, 1994). When applied, these criteria generally provide protection to greater than 98% of the juvenile salmon, for fish larger than the button-up fry life, under the coldest water temperatures likely to exist when these fish are present. Generally, Chinook and steelhead fry are not migratory, but are sometimes prone to be swept downstream by freshet flows, and will also move around to forage. Occurrence of either of these events could place fry in the vicinity of the CGS intake screens and vulnerable to entrainment. Zero-age juvenile Chinook and steelhead are actively foraging, moving from shallow waters to deeper waters depending on a number of factors. In a fyke net study conducted in the vicinity of the CGS intake, zero-age fall Chinook salmon occurred primarily in shoreline areas of reduced current velocity (see Figure 1), but were present throughout the river cross section during their early rearing and outmigration period (Dauble et al, 1989). These fish are susceptible to entrainment through the CGS intake screens.

References

Bates, Ken, and Fuller, R. 1992. Salmon Fry Screen Mesh Study. WDFW, Olympia,WA.

Beecher, H. 1993. Draft Report - Screen Mesh Evaluation for Water Diversions. WDFW, Olympia, WA.

Bell, Milo C. 1990. Fisheries Handbook of Engineering Requirements and Biological Criteria. Prepared for the North Pacific Division of the Army Corps of Engineers, Portland, Oregon.

Dauble, Dennis D., T.L. Page, and R.W. Hanf Jr.. 1989. Spatial Distribution of Juvenile Salmonids in the Hanford Reach, Columbia River. Fishery Bulletin, U.S. 87:771-790, Environmental Sciences Department, Pacific Northwest Laboratory, Richland, WA.

Mueller, R.P., Abernathy, C.S. and Neitzel, D.A. 1995. A Fisheries Evaluation of the Dryden Fish Screening Facility. Pacific Northwest National Laboratory. Prepared for Bonneville Power Administration, Portland, Oregon.

NMFS. 2011. Anadromous Salmonid Passage Facility Design. Portland, Oregon. http://www.nwr.noaa.gov/hydropower/hydropower_northwest/hydropower_in_the_nw.html)

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PNNL. 1994. Data Summary for the Dryden Screens Fisheries Evaluations. Unpublished Report.

August 7, 2013

MEMORANDUM FOR: Hydro Division Files

CC: Rich Domingue

FROM: Bryan Nordlund, P.E

SUBJECT: Columbia Generating Station (CGS) – Intake Screens Assessment and Recommendations for Modifications

In the course of my work on the Coordinating Committees for the hydroprojects in the Upper Columbia River, I have reviewed numerous reports and studies on juvenile salmonid migration from below Chief Joseph Dam to McNary Dam. In addition, the Coordinating Committees are currently in the process of developing information on the life history of fall Chinook salmon, particularly when they enter the migratory stage of their life cycle. In addition, a sub-committee established through Clean Water Act license conditioning requirements from the Washington Department of Ecology is specifically researching Hanford Reach fall Chinook (HRFC) spawning and rearing, and periodically reports to the Priest Rapids Coordinating Committee. Finally, I have spent the majority of my 29 year Federal service career with the National Marine Fisheries Service involved in fish facility design development and assessment, including fish screens that range in capacity from a fraction of a cubic foot per second (cfs) to 6,000 cfs. All of these efforts provide information that pertain to applying best professional judgment regarding the potential of the CGS intake to affect fish listed under the Endangered Species Act (Upper Columbia River spring Chinook and steelhead and Mid Columbia River steelhead) as well as salmonids protected by the Magnuson-Stevens Fishery Conservation and Management Act (MSA), which include all Chinook and coho salmon in the Columbia River Basin).

As such, I offer my professional opinion of the CGS intake system.

Fish Presence

Salmonids spawn, rear and migrate through the vicinity of the Columbia River occupied by the CGS intake. Portions of each life stage of the HRFC occupy the vicinity of the site. Per material provided by Washington Department of Ecology CGS Screen Design Report:

> "This intake was selected to minimize the impact of the make-up water withdrawal from the Columbia River, with particular emphasis on salmonid fry. Two characteristics of this intake minimize fish entrainment. First, the intake location is well offshore where the number of downstream salmonid fry are expected to be relatively small. Second, the low

intake approach velocities near the perforated pipe are on the order of 0.2 – 0.4 feet per second (fps)."

While these facts likely prevent some fish from being impinged or entrained, the screen design could be further improved to markedly lessen the potential for salmonid entrainment or impingement to nearly zero, as evidenced in many evaluations of juvenile fish screens designed and operated to NMFS (and Washington Department of Fish and Wildlife) screen design standards.

Screen Design

I reviewed the CGS screen design report, at least most of it. I could not read the small faint font describing most features on the two sheets of drawings, but I think the rest of the document fills in enough detail for me to assess whether these screens achieve NMFS design standards. The CGS screen does not meet NMFS screen design standards, as described below.

Screen Cleaner

There is no automated screen cleaning system on the Columbia Generating Station (CGS) intake screens, which is a required NMFS design criterion for most screens.

> **11.10.1.2 Screen Cleaning (Active Screens):** *Active screens* must be automatically cleaned to prevent accumulation of debris. The screen cleaner design should allow for complete debris removal at least every 5 minutes, and operated as required to prevent accumulation of debris. The head differential to trigger screen cleaning for intermittent type cleaning systems must be a maximum of 0.1 feet over clean screen conditions or as agreed to by NMFS. A variable timing interval trigger must also be used for intermittent type cleaning systems as the primary trigger for a cleaning cycle. The cleaning system and protocol must be effective, reliable, and satisfactory to NMFS.

For small flow screens (less than 3 cfs) with specific design features, a passive screen design (i.e. no automated cleaner) may be acceptable. However, the CGS intake screens divert up to 25,000 gallons per minute, or about 56 cubic feet per second (cfs), so these screens would not qualify for consideration as a passive screen by NMFS standards.

> **11.10.1.3 Passive Screens:** A *passive screen* should only be used when all of the following criteria are met:
> - The site is not suitable for an *active screen*, due to adverse site conditions.
> - Uniform approach velocity conditions must exist at the screen face, as demonstrated by laboratory analysis or field verification.
> - The debris load must be low.
> - The combined rate of flow at the diversion site must be less than 3 cfs.
> - Sufficient ambient river velocity must exist to carry debris away from the screen face.
> - A maintenance program must be approved by NMFS and implemented by the water user.
> - The screen must be frequently inspected with debris accumulations removed, as site conditions dictate.
> - Sufficient stream depth must exist at the screen site to provide for a water column of at least one screen radius around the screen face.
> - The screen must be designed to allow easy removal for maintenance, and to protect from flooding.

Screen Submergence

The water surface elevation (341.75 feet) at minimum tailwater does not provide sufficient submergence of the top of the screen (elevation 341.0 feet). With only 0.75 feet of submergence, the water velocity directly between the water surface and the top of the screen can exceed the juvenile salmon swimming ability, and could potentially capture fish in the screens flow net fish until they fatigue, or become prey.

To demonstrate this risk, assuming half of the flow (28 cfs) enters the top half of the screen, the flow area would be 0.75 feet by 3.5 feet (2.6 square feet) at the top of the screen, and 2.5 feet by 3.5 feet (8.7 square feet) at the screen mid-point elevation, and the corresponding water velocity ranges between 10.7 fps and 3.2 fps. Fish that pass above the screen would be required to escape these velocities to escape the flow path above the screen. Since salmonid fry can swim at burst velocity of about 1.3 fps (Bell 1991), the only means for escape is if river velocity dominates the velocity produced by the flow net into the screens. This is not certain and not a constant. Larger juvenile fish face a similar risk - parr sized salmonids can swim at burst speeds up to 2.1fps (Bell 1991), and smolts a bit faster. Since the CGS screens are 42 inches in diameter, they should be submerged at least one screen radius, or 21 inches at minimum water elevation, per the criterion below.

> **11.11.1.2 Submergence:** *End of pipe screens* must be submerged to a depth of at least one screen radius below the minimum water surface, with a minimum of one screen radius clearance between screen surfaces and natural or constructed features.

Screen Face Material

The outer CGS screen face material is perforated plate with 3/8-inch diameter perforations. NMFS design standards require a maximum 3/32-inch diameter hole for perforated plate. From studies at the Cowlitz Trout Hatchery (Beecher, 1993), we know that 1/8th inch diameter perforated plate openings will entrain steelhead fry. Presumably, the 3/8th inch perforations at the CGS screen could entrain larger juvenile salmonids. Using an equation to predict fish entrainment (Bell, 1991), 3/8th inch openings could potentially entrain juvenile salmonids as large as 70-80 mm, depending on the body height of the fish. Coupled with the shallow depth of water above the screen face as described above, at low levels of Columbia River stream flow juvenile fish could be entrained. A 3/8th inch perforated plate screen has never been tested for salmonid entrainment that I'm aware of, because it intuitively makes sense that any diameter hole larger than 3/32nd inch would entrain small juvenile salmon.

The CGS screen report states that no impingement has been observed since 1978, but this observation is limited to semiannual inspections. If fry are present (presumably they are, since Chinook spawning occurs in the Hanford Reach just upstream of the CGS), they would likely be entrained through the 3/8th inch openings rather than be impinged on the screen face. If fish fatigue near the screens, larger juvenile salmon might be impinged, and unobserved, especially at low river water surface elevations.

11.7.1.1 Circular Screen Openings: Circular screen face openings must not exceed $^{3}/_{32}$ inch in diameter. Perforated plate must be smooth to the touch with openings punched through in the direction of approaching flow.

Screen Approach Velocity

The information provided in response to our Additional Information Request states that the screen approach velocity (i.e. water velocity perpendicular to the screen face) is 0.5 feet per second (fps). NMFS screen criteria requires a screen approach velocity of less than 0.4 fps. However, based on my calculations using the provided screen dimensions and the maximum diverted flow amount, the screen approach velocity is less than 0.2 fps. I suspect the approach velocity provided in the CGS screen report was calculated based on the screen open area, which is 40%. NMFS screen criterion for approach velocity does not deduct for the percent open area. If the velocity I calculated for the CGS screens is divided by 40%, the result is 0.5 fps, matching the CGS screen report value. Therefore, the CGS intake screen does meet NMFS criterion for screen approach velocity.

11.6.1.1 Approach Velocity: The *approach velocity* must not exceed 0.40 ft/s for *active screens*, or 0.20 ft/s for *passive screens*. Using these approach velocities will minimize screen contact and/or impingement of juvenile fish. For screen design, *approach velocity* is calculated by dividing the maximum screened flow amount by the vertical projection of the *effective screen area*. An exception may be made to this definition of *approach velocity* for screen where a clear egress route minimizes the potential for impingement. If this exception is approved be NMFS, the *approach velocity* is calculated using the entire *effective screen area*, and not a vertical projection. For measurement of approach velocity, see Section 15.2.

Effective screen area - the total submerged screen area, excluding major structural members, but including the screen face material. For rotating drum screens, *effective screen area* consists only of the submerged area projected onto a vertical plane, excluding major structural members, but including screen face material.

Conclusion

Overall, the CGS falls short of achieving NMFS screen design standards. Fry and parr sized salmonids could be entrained through 3/8-inch diameter perforated plate screen, or become fatigued and more susceptible to predation and/or entrainment if they swim near the screens.

The minimum screen submergence violation may or may not be an issue, depending on the frequency and timing of occurrence of the minimum water surface elevation relative to the life stage and swimming ability of salmonids present near the screen when low water surface elevation occurs.

Although the CGS report states that debris is not an issue on the screens and the screens self-clean, I doubt this would remain the case if the screen mesh were replaced to achieve NMFS criterion to provide protection for juvenile salmonids, especially fry from the Hanford Reach. All intakes on the Columbia and Snake rivers should meet this standard, especially those immediately downstream of the most productive Chinook spawning areas on the mainstem at Hanford Reach.

To correct design deficiencies, I would recommend:

1) Design and installation of a waterjet back spray cleaning system.
2) Replacement of screen mesh with 3/32" stainless steel perforated plate.
3) Balance of screen approach velocities by installing an internal baffle with porosity varied to distribute flow evenly over the entire screen surface.
4) Install the screens at a lower elevation, if feasible.